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A Discussion of the Etiology of So-Called Aniline Tumors of the Bladder

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AN OUTPUT STUDY OF USERS AND NON-USERS OF TOBACCO IN A STRENUOUS PHYSICAL OCCUPATION *

J. P. BAUMBERGER, EDNA E. PERRY, AND E. G. MARTIN

(From the Laboratory of Physiology, Stanford University)

INTRODUCTION

IN a previous paper, the first of a series of articles dealing with the general problem of the significance of the use of tobacco in industry, some observations were reported on the effects of smoking on efficiency in a strenuous *mental* occupation (1). The present paper is concerned with the second phase of the general topic: namely, the relation of the use of tobacco to efficiency in a strenuous *physical* occupation. In this investigation, as in our previous report, we have adopted output as the criterion of efficiency (2).

An output study requires a routine occupation in which the same process is repeated many times during the day and, to be wholly satisfactory, requires also that the number of repetitions be entirely dependent on the speed of the individual worker, unaffected by the rate at which machinery is driven. Obviously tobacco effects, if any exist, would be most likely to appear in a very strenuous occupation. The occupation to be selected for study should, therefore, be routine, physically strenuous, and dependent on individual initiative.

* Received for publication Dec. 14, 1920.

After some search we decided on bottle making as meeting these conditions satisfactorily. Permission was obtained to make an output study in a large glass bottle manufacturing plant, which operates thirty-five bottle-making machines and employs 500 persons. We wish to take this opportunity of thanking the superintendent and the personnel of the factory for their courteous treatment of us during the three weeks of the investigation.

PROCESS

The process of glass blowing may be briefly described as follows: The old method of blowing glass bottles by mouth has been largely abandoned except for small special orders, and this highly skilled work is now done by machinery manipulated by a skilled "gatherer" and "cutter" and inexperienced helpers. In some machines the whole process is carried out automatically and only an unskilled attendant is required. In the majority of machines, however — and it was with this type of machine that our work was concerned — the gatherer regulates the speed of the machine by his own motions. The

machines are located at one end of an oval tank containing the fused glass, which is kept at a temperature of 2650° F. The wall of the tank is perforated with working holes at intervals of about 12 feet, and foot benches of appropriate height for the gatherers are situated at each hole. The machine is located at the left of the foot bench and consists usually of two revolving tables, the first of which bears a number of iron blanks in which the neck of the bottle and a depression in the center can be formed. The second revolving table carries molds in which the final form can be given to the bottle. The operation is as follows:

The gatherer stands on the foot bench at the working hole with a "punty" in hand. This is an instrument 43 inches long, consisting of an iron rod with a wooden handle at one end and a clay ball on which the glass is collected, at the other end. The gatherer has his back toward the machine and holds the punty handle with both hands, allowing the clay ball to touch the surface of the fused glass. The iron rod of the punty rests on an iron support ("dog leg") at the edge of the working hole, while the gatherer revolves the punty until sufficient glass adheres to form a "gob" of the size required to make the proper weight bottle. The gatherer then turns to the left and, suspending the gob over the mouth of the blank, allows the glass to drip off. When the proper amount has fallen, the cutter clips the stream of glass with a pair of shears. The gatherer then turns back to the hole and again inserts the punty. The motions of the gatherer are exceedingly rapid and accurate and as many as twenty-six 2-ounce gobs may be gathered in one minute.

The cutter sits on a stool at the edge of the foot bench and clips off the stream of glass from the punty as it falls into the blank; he then pulls a lever which brings down a plunger into the center of the blank, shaping the neck and making a depression in the glass, revolves the table so that the bottle is partially blown automatically, greases (with a graphite covered plunger) another blank, and is ready to receive the next gob of glass.

The "take-out boy" (unskilled) is seated on a stool opposite the cutter; he opens the blank, removes the half-blown bottle by means of pincers, and drops it into a mold on the mold table. The second helper is seated at the mold table which he revolves so that the bottle is fully blown by an automatic blower, and passes under a torch to smooth the mouth. He then opens the mold, places the finished bottle on a table, and closes the mold.

The "carrying-in boy," by means of a "carrying stick" (an asbestos-covered, long handled implement) transfers the bottles, a row at a time, into the "tempering lehr," the floor of which moves the bottles very slowly through an oven of decreasing temperature until the bottles are taken out cool at the other end, where they are packed.

In the Lynch machine, this whole process is carried out by a gatherer and a carrying-in boy, the gatherer regulating the speed of the machine just as he does in the type described above. In the Lynch type in the process of dripping the gob into the blank, the gatherer touches with his punty a lever which puts the whole machine into motion. Thus, for each gob gathered the machine makes one complete revolution.

Operatives

The helpers, carrying-in boys, and take-out boys are all unskilled, unorganized laborers and, though called "boys," are usually over 20, the carrying-in being done by men of 40 or over, who are not quick enough for the other work. During the war many women were taken on as helpers, and some white and some colored women have continued in this work. The

labor turnover among the unskilled employees is very high.

The gatherers alternate every half hour in the processes of cutting and gathering. On the Lynch machine three gatherers operate two machines; one gatherer is assigned to each machine on which he works 40 minutes, and then rests and oils the machine for 20 minutes; the third man works 20 minutes on each machine and rests and oils the two machines for 20 minutes. The gatherers are the only skilled workers on the machines and have inherited the pride of the craft of glass blowing and are very proud of their dexterity and speed. Indeed, a speedy man is usually the center of attraction for all who happen not to be at work at the time. This pride buoys the men up and increases their output, as will be shown in another paper. The turnover for gatherers is very slight, and it is not rare to find men who have worked over five years in the same plant.

The average age of the eighty-five gatherers studied was 36 years, of which an average of twenty years had been spent in the glass industry. A study of the correlation of age and output gave negative results as did also a study of correlation of overweight and underweight and output. The men averaged 4 pounds overweight, on the basis of the biometric tables of the Provident Life & Trust Co., which seems to indicate that the work is not too strenuous. The men are unionized and work under definite regulations as to hours' and weeks' work. The shifts are from 7 A.M. to 3 P.M., 3 P.M. to 11 P.M., and 11 P.M. to 7 A.M., and the men work for a week on each shift. The plant runs from Monday 7 A.M. to Saturday 12 M. Two weeks' vacation (without pay) between June 15 and September 15 must be taken. Apprenticeship is for three consecutive years. A benefit association is maintained by the Glass Blowers' Association of the United States and Canada. The gatherers are largely of native stock, with little schooling, as the average length of experience shows, and are, on the whole, a very steady, clean-lived group of men. Many expressed the belief that their work was so hazardous and hard that dissipation could not be indulged in without great risk to their health and injury to their efficiency. The men earn from $8 to $10 a day, working on a piece-work basis except when the machines break down, and then they are paid by the hour. The men claim that they can estimate their speed closely enough to calculate their output for the day, but in some cases the carrying-in boy scores each load of bottles he places in the tempering lehr.

Method

The output records were obtained by passing from one machine to another each half hour and counting the number of gobs of glass gathered by each man in a period of from one to five minutes. The data, therefore, show *output rate* only and are not to be construed as actual output. It was found that actual output is not a dependable criterion of the working capacity of the individual, as in this trade machine breakdown and minor delays, such as result from impurities adhering to the punty-head, are a constant and unaccountable factor entirely independent of the workers' efficiency. It is obvious, however, that output would, in general, correspond to differences in rate of gathering between individuals.

The counting was done by means of a tally register and the timing by means of a stop-watch. The records were kept on a separate card for each man together with the weight of the bottle made and data obtained by a personal interview as to age, height, weight, marital status, years' experience, and smoking and chewing habits. All counts were made at times when the machinery was working without trouble,

and in no case was a count made when any accidental obstruction to the full speed of the worker was present. The gathering had an extremely uniform rate for each individual, and it was found that one minute was a long enough period in which to obtain a count characteristic of the operator. The investigation was carried on for about three weeks and 1,569 hourly counts were made — *i.e.*, an average of 20.3 hourly counts per man.

TABLE 1. — NUMBER OF MEN IN EACH HABIT GROUP

Number of men included in habit groups	76
Non-users of tobacco	6
Non-smokers	13
Smokers	63
Chewers	22
Light smokers	23
Heavy smokers	40
Non-smokers who chew	7
Light smokers who chew	8
Heavy smokers who chew	7
Light smokers who do not chew	15
Heavy smokers who do not chew	33
Non-chewers	54
Non-chewers who smoke	48

Habits

The smoking or chewing habits of the men were obtained by questioning them directly and by observation and indirect conversation. They appeared to be honest and straightforward in their answers and were all on the best of terms with the investigator. The following arbitrary classification seemed logical, on the basis that about the same amount of tobacco is involved in each case.

Persons who smoked more than ten cigarettes per day, or more than one cigar per day, or more than two pipefuls of tobacco per day were called heavy smokers. Those who smoked less than this were called light smokers, and chewers and non-users of tobacco were classified separately. Table 1 gives the habit groups and the number of men in each class. For lack of adequate data, nine men had to be omitted from the habit groups, leaving seventy-six that were included. Only 8 per cent. of the men do not use tobacco, while 83 per cent. smoke, 29 per cent. chew, and 20 per cent. both smoke and chew.

Output Rate and Weight of Bottle

In order to determine the efficiency of the men grouped according to their habits, it is necessary to compare their actual output rates. The men were, however, working on bottles of a number of different sizes

TABLE 2. — ACTUAL AVERAGE HOURLY OUTPUT RATE AND PERCENTAGE HOURLY OUTPUT RATE OF ALL WORKERS

Hour	7–8	8–9	9–10	10–11	11–12	12–1	1–2	2–3
Actual Output Rate of All Workers (in Number of $8\frac{1}{2}$-Ounce Bottles per Minute)								
Mean	*13.6*	*13.59*	*13.53*	*13.75*	*13.53*	*13.45*	*13.59*	*13.44*
Standard deviation	2.32	1.98	2.02	1.98	1.77	1.99	2.01	1.88
Probable error of mean ±	0.186	0.141	0.146	0.141	0.155	0.149	0.15	0.14
Coefficient of variability	17.1	14.6	14.9	14.4	13.0	14.8	14.8	14.0
Percentage Hourly Output Rate of All Workers								
Mean	*99.2*	*100.5*	*100.04*	*100.3*	*100.44*	*100.01*	*100.08*	*99.3*
Standard deviation	6.0	5.4	4.2	4.16	5.4	5.2	4.48	5.3
Probable error of mean ±	0.48	0.386	0.30	0.29	0.46	0.39	0.35	0.39
Coefficient of variability	6.0	6.0	4.17	4.14	5.36	5.29	4.46	5.31

and weights. Each machine was assigned a particular weight bottle to be made for a day, or weeks, as the case might be. It requires different lengths of time to gather different weight gobs of glass, but this relationship is not a direct proportion; thus, six and five-tenths 55-ounce gobs can be gathered in a minute, while only twenty-two and five-tenths $1\frac{3}{4}$-ounce gobs can be gathered in the same time. So that the outputs of all the men would be comparable, they were reduced to output for a standard-sized bottle. This was accomplished in the following manner: The average output for each individual who had worked on a certain weight bottle was plotted on co-ordinate paper with the horizontal axis as the number of gobs of glass gathered in a minute, and the vertical axis as weight of the gob in ounces. Having plotted all the individual average outputs for all the different weight bottles that had been handled, the grand average for each weight was also plotted. A curve was then drawn which coincided as closely as possible with the loci of the grand averages. Such a smoothed curve can be drawn with great accuracy according to Bayliss (3). The curve is shown in Figure 1. It was then assumed that the loci of the curve represented the relation existing between the weight of the gob of glass gathered and the number of gobs that could be gathered in one minute. The largest number of individuals and records had been involved in determining the grand average output of $8\frac{1}{2}$-ounce bottles, and the locus of this point seemed to be in good general conformity with the curve as a whole; it was, therefore, selected as a standard.

An example will best serve to illustrate the method used to reduce the output of one individual operator to the standard. Operator 1 gathered twenty-four $1\frac{3}{4}$-ounce gobs of glass in one minute. Referring to Figure 1 we find that twenty-two and five-tenths is the grand average for $1\frac{3}{4}$-ounce bottles, also that thirteen and three-tenths is the grand average for $8\frac{1}{2}$-ounce bottles. Therefore, Operator 1 would be expected to make more than thirteen and three-tenths $8\frac{1}{2}$-ounce bottles in proportion as he had made more than the expected number of $1\frac{3}{4}$-ounce bottles; in other words, the

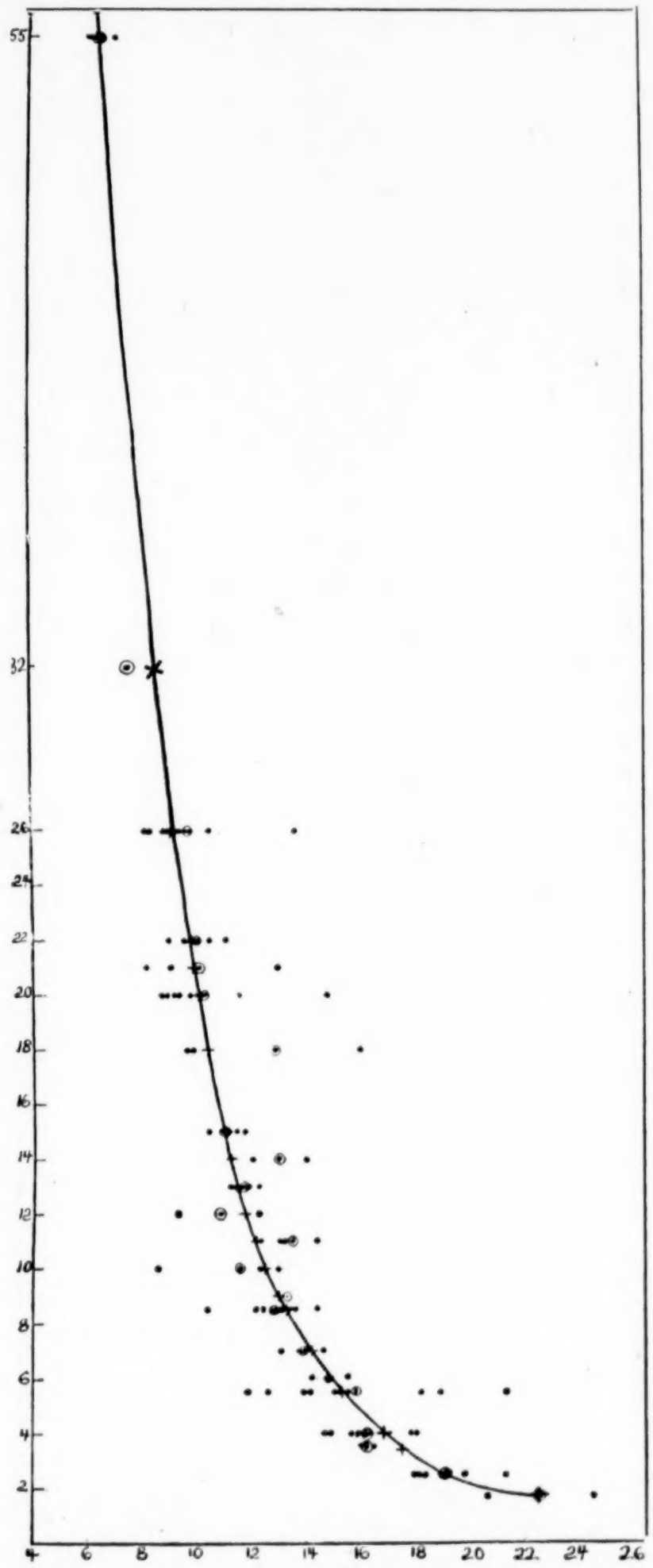

FIG. 1. — Relation of gathering rate to weight of gob. Horizontal axis = number of gobs gathered per minute; vertical axis = weight of gobs in ounces; dots = average gathering rates; circles = grand average gathering rates; crosses = theoretical gathering rates.

TABLE 3. — HOURLY OUTPUT RATE BY HABIT GROUPS

Hour	7–8	8–9	9–10	10–11	11–12	12–1	1–2	2–3
All Non-Smokers								
Mean	*13.27*	*14.12*	*13.89*	*13.96*	*14.0*	*13.75*	*13.96*	*14.04*
Standard deviation	1.25	1.44	1.45	1.74	1.36	1.87	1.69	1.82
Probable error of mean ±	0.34	0.27	0.27	0.32	0.29	0.364	0.316	0.34
Coefficient of variability	9.4	10.2	10.4	12.5	9.7	13.6	12.1	13.0
All Smokers								
Mean	*14.05*	*13.9*	*13.95*	*14.11*	*14.0*	*13.89*	*13.87*	*13.82*
Standard deviation	2.4	2.33	2.24	2.16	1.91	2.1	2.1	1.97
Probable error of mean ±	0.23	0.199	0.188	0.18	0.191	0.183	0.183	0.175
Coefficient of variability	17.1	16.6	16.0	15.2	13.6	15.1	15.1	14.2
All Chewers								
Mean	*13.34*	*13.71*	*13.46*	*13.71*	*14.09*	*13.46*	*13.42*	*13.62*
Standard deviation	1.22	1.51	1.21	1.47	1.09	1.58	1.39	1.48
Probable error of mean ±	0.188	0.208	0.165	0.202	0.177	0.22	0.19	0.198
Coefficient of variability	9.15	11.0	8.99	10.7	7.73	11.7	10.4	10.9
All Non-Users of Tobacco								
Mean	*13.5*	*14.0*	*14.6*	*14.0*	*13.9*	*14.2*	*14.3*	*14.5*
Standard deviation	1.0	1.12	1.07	1.12	1.2	1.48	1.07	1.52
Probable error of mean ±	0.275	0.308	0.294	0.308	0.357	0.4	0.294	0.42
Coefficient of variability	7.4	8.0	7.3	8.0	8.6	10.4	7.45	10.4
All Heavy Smokers								
Mean	*14.67*	*13.92*	*14.17*	*14.4*	*14.24*	*14.29*	*14.44*	*14.05*
Standard deviation	2.68	2.52	2.32	2.2	2.02	2.23	1.36	1.9
Probable error of mean ±	0.310	0.266	0.236	0.224	0.24	0.232	0.145	0.203
Coefficient of variability	18.2	18.1	16.4	15.3	14.2	15.5	10.0	13.6
All Light Smokers								
Mean	*13.44*	*13.54*	*13.22*	*13.5*	*13.5*	*13.06*	*13.31*	*13.44*
Standard deviation	1.69	1.29	1.29	1.41	1.36	1.55	1.99	1.99
Probable error of mean ±	0.288	0.19	0.214	0.212	0.256	0.244	0.308	0.308
Coefficient of variability	12.6	9.5	10.9	10.4	10.1	11.9	14.9	14.8
Heavy Smokers Who Chew								
Mean	*13.5*	*13.12*	*14.06*	*13.83*	*14.07*	*14.0*	*13.5*	*13.83*
Standard deviation	1.29	1.22	0.68	0.9	1.06	0.7	0.7	0.48
Probable error of mean ±	0.35	0.29	0.152	0.2	0.269	0.167	0.167	0.104
Coefficient of variability	12.3	9.3	4.85	6.5	7.54	5.0	5.18	3.48

TABLE 3.—HOURLY OUTPUT RATE BY HABIT GROUPS (CONTINUED)

Hour	7–8	8–9	9–10	10–11	11–12	12–1	1–2	2–3
Heavy Smokers Who Do Not Chew								
Mean	*14.67*	*14.26*	*14.27*	*14.56*	*14.29*	*14.39*	*14.43*	*14.11*
Standard deviation	2.92	2.68	2.62	2.44	2.32	2.46	2.30	2.20
Probable error of mean ±	0.386	0.325	0.306	0.28	0.312	0.292	0.27	0.27
Coefficient of variability	19.9	18.8	18.4	16.7	16.2	17.1	16.0	15.5
Light Smokers Who Chew								
Mean	*13.5*	*13.8*	*13.0*	*13.37*	*14.1*	*13.38*	*13.17*	*13.39*
Standard deviation	0.17	1.42	1.25	1.16	0.65	1.62	1.56	1.67
Probable error of mean ±	0.047	0.318	0.296	0.276	0.195	0.363	0.35	0.373
Coefficient of variability	1.26	10.3	9.6	8.76	4.65	12.1	11.8	12.5
Light Smokers Who Do Not Chew								
Mean	*14.09*	*13.9*	*13.93*	*13.93*	*13.6*	*14.0*	*14.04*	*13.75*
Standard deviation	1.89	0.95	1.35	1.45	1.44	1.04	1.82	1.96
Probable error of mean ±	0.367	0.165	0.24	0.26	0.307	0.202	0.34	0.382
Coefficient of variability	13.5	6.8	9.7	10.4	10.6	7.41	13.0	14.3
Chewers Who Do Not Smoke								
Mean	*13.07*	*14.21*	*13.21*	*13.93*	*14.0*	*13.34*	*13.64*	*13.64*
Standard deviation	1.48	1.67	1.39	2.13	1.48	2.12	1.81	1.96
Probable error of mean ±	0.37	0.42	0.37	0.54	0.445	0.583	0.46	0.49
Coefficient of variability	11.3	11.7	10.5	15.3	10.6	15.9	13.3	14.3

following formula was applied: $x : 13.3 :: 24 : 22.5$, and solving for x we have 14.19 as the number of standard-sized bottles which Operator 1 would make in one minute. Individuals who had worked on several different weight bottles were found to have outputs for the different weights corresponding to our curve, confirming the validity of our method. Furthermore, as will appear in a subsequent paper, the relationship of weight of gob to the number of gatherings per minute involves the time of gathering, of transfer back and forth, and of dropping the glass. The last two factors vary in an arithmetical progression, and the time of gathering, in a geometrical progression. The form of our curve is a logical outcome of these relationships.

The formula given above was used to reduce the output to terms of a standard-sized bottle so that the men could be directly compared as to output. The actual average output rate of the men in $8\frac{1}{2}$-ounce bottles per minute for each hour during the day's work, calculated by the method described above, is given in Table 2. The percentage output is also given in Table 2 and serves as a check on the former, as the percentage output is determined directly from the actual number of bottles which each man makes, reduced to a percentage on the basis of his average as

100. The two sets of figures vary in the same manner throughout the day, except for minor differences which prove to be due to the smoothing effect of the formula method, for if the percentage output curve is smoothed it approaches the actual output curve even more closely.

Output Rate by Habit Groups

In order to determine the output of each group the standardized output records were added and the mean output rate per minute for each hour was obtained. For the eighty-five men studied the mean rate per minute for the day was 13.56, and for the seventy-six men in the habit groups the output was 13.99. The output rate for each hour was about the same throughout the day (see Table 2), showing that fatigue does not affect the output rate to any appreciable extent. Table 3 shows that all the habit groups are equal in this regard. The question of fatigue will be taken up in a separate paper.

The mean output rate for the day for each of the thirteen habit groups is shown in Table 4. The highest output is found in the heavy smokers who do not chew, and the lowest in the light smokers who chew. The difference between these two extremes is 1.01 bottles per minute, or 7.2 per cent. of the grand average output. Industrially, this is an important difference, amounting to more than a thousand bottles in a twenty-four-hour day. Statistically, however, the difference is so slight that before we can draw any conclusions, some statistical criterion must be applied to determine whether or not it has any significance.

The probable error of the mean can be used to determine the degree of unreliability of the mean; therefore, if we are comparing two means, the significance of the difference between them will be determined by the chances that one mean will coincide with the other. The chances that the difference between the means is significant are 1 : 1 if the probable error of the difference is contained once in the difference; 4.5 : 1 if contained twice; and 21 : 1 if contained three times. It is usually considered that, in order to be significant, the difference between two means must contain the probable error of the difference twice, and in order to have a degree of certainty, must contain it three times. We have, therefore, arranged in Table 5 the differences between groups that can be compared and the number of times the probable error of the difference is contained in these differences.

TABLE 4. — MEAN OUTPUT RATE FOR DAY BY HABIT GROUPS

Group	True Mean	Standard Deviation	Coefficient of Variability	Probable Error of Mean
Heavy smokers who do not chew	14.33	2.4	16.9	±.101
Non-users	14.24	1.32	9.25	±.130
All non-chewers	14.24	2.3	16.1	±.078
Non-chewers who smoke	14.19	2.17	15.2	±.078
All heavy smokers	14.14	2.32	16.4	±.093
Mean of all habit groups	13.99	..	..	...
All smokers	13.93	2.13	15.3	±.065
Light smokers who do not chew	13.88	1.54	11.0	±.099
All non-smokers	13.87	1.66	12.0	±.112
Heavy smokers who chew	13.72	0.3	2.2	±.025
All chewers	13.59	1.4	10.3	±.066
Non-smokers who chew	13.44	1.82	13.3	±.169
All light smokers	13.37	1.61	12.4	±.089
Light smokers who chew	13.32	1.37	10.3	±.114

From Table 5 it appears that chewing has a marked effect on output rate, while smoking has little effect. The non-user group may be considered as a standard, and we find that the whole group of non-chewers coincides with it in output rate, but the chewers fall far below these two groups, the difference being significant as the probable error of the difference is contained 2.7 times. The difference between smokers who do not chew and the non-users is too small to be of significance;

therefore, it appears that smoking has less effect on output rate than chewing. When we separate the smokers who do not chew into light and heavy smokers, no significant difference appears between the non-users and the light smokers or between the non-users and the heavy smokers. The heavy smokers who do not chew do slightly better than the non-users, but the difference is not statistically dependable. The light smokers who do not chew, however, do less well than the non-users, but the chances that this is significant are only 1 : 1. We cannot offer an explanation of the fact that the light smokers have a lower output rate than the heavy smokers. A difference of the same nature, however, exists between the output of heavy and light smokers as a whole, the probable error of the difference being contained in the difference 1.9 times, and also between the heavy and light smokers subdivided into chewers and non-chewers, the probable error of the difference being contained 1.1 and 1.0 times, respectively.

The fact that chewing has a much more marked effect on output rate than smoking is further brought out by a comparison of heavy smokers who chew with heavy smokers who do not chew, in which the difference is large enough to contain the probable error of the difference 1.8 times, and in like manner among the light smokers where the difference contains the probable error of the difference 1.2 times. These comparisons are also given in Table 5 and show that chewers have in every case a markedly lower output rate.

Table 6, in which the groups holding the highest and lowest hourly records are given, shows that the workers who chew in no case make a highest output rate record, but in seven out of eight of the hours make a lowest record. The actual output rates are given in Table 3.

TABLE 5.—COMPARISON OF HABIT GROUPS, SHOWING SIGNIFICANCE OF DIFFERENCES

Groups		Algebraic Difference from Mean of First Group	Probable Error of Difference	Number of Times Probable Error of Difference is Contained in Difference
First Group	Second Group			
Non-users	All chewers	−0.65	0.24	2.7
"	Non-chewers	....	....	....
"	Smokers who do not chew	−0.05	0.28	....
"	Light smokers who do not chew	−0.36	0.34	1.0
"	Heavy smokers who do not chew	+0.09	0.34	....
All heavy smokers	All light smokers	−0.77	0.41	1.9
Heavy smokers who do not chew	Heavy smokers who chew	−0.61	0.33	1.8
Light smokers who do not chew	Light smokers who chew	−0.56	0.48	1.2
Heavy smokers who do not chew	Light smokers who do not chew	−0.45	0.45	1.0
Heavy smokers who chew	Light smokers who chew	−0.40	0.37	1.1

Discussion

From the foregoing data it appears that workers who chew have a much lower output rate than those who only smoke or who do not use tobacco in any form. The light smokers, however, do show some inferiority in output rate and the heavy smokers a very slight superiority, although these differences are too small to be statistically dependable. The difference between the light and heavy smokers is apparently significant. The fact that light smokers have a lower output rate than heavy smokers is difficult to explain but may be an indication that insufficient use of tobacco has more deleterious effects than a larger use which might confer an immunity

that would be lacking in the case of light smokers. This explanation is entirely a surmise, but should be followed up.

The low output of chewers may be due to a greater absorption of nicotine into the system than takes place from smoking. Some reason for this is obvious when we consider that in smoking at least half the nicotine is lost in the smoke from the burning point and that a large part of the nicotine in the inhaled smoke may be exhaled before it is absorbed. This is quite likely, as smoke can be drawn through several wash bottles without losing all its nicotine, because the alkaloid is probably adsorbed on the surface of liquid particles in the smoke which are notably difficult to absorb in a wash bottle. (This point will be brought out in a paper to follow shortly.) In chewing tobacco, on the other hand, the saliva of the chewer seems to have ample opportunity to absorb the nicotine of the tobacco, and from the saliva the mucous lining of the mouth may absorb the poison. Furthermore, in most chewing a certain amount of saliva is swallowed, which gives abundant opportunity for absorption of nicotine. It is possible, therefore, to offer an explanation for the fact that chewers have a lower output rate than smokers on the basis of the relative nicotine absorption, although until actual absorptive studies of the two groups have been made, such an explanation can be only tentative.

TABLE 6.—HABIT GROUPS HOLDING HIGHEST AND LOWEST HOURLY OUTPUT RATE RECORDS

Hour	Highest Average Hourly Output Rate	Hour	Lowest Average Hourly Output Rate
1	Heavy smokers who do not chew	1	Chewers who do not smoke
2	Heavy smokers who do not chew	2	Heavy smokers who chew
3	Non-users.....	3	Light smokers who chew
4	Heavy smokers who do not chew	4	Light smokers who chew
5	Heavy smokers who do not chew	5	Light smokers who do not chew
6	Heavy smokers who do not chew	6	Chewers who do not smoke
7	Heavy smokers who do not chew	7	Light smokers who chew
8	Non-users.....	8	Light smokers who chew

Conclusions

1. Smoking has little effect on output rate in the strenuous physical occupation studied by us.
2. Chewing markedly lowers output rate in this strenuous physical occupation.
3. Light smokers have a slightly lower output rate than heavy smokers in this strenuous physical occupation.

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A SURVEY OF CARBON MONOXIDE POISONING IN AMERICAN STEEL WORKS, METAL MINES, AND COAL MINES *

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THIS report is the result of a survey, chiefly in mines and about blast furnaces, to obtain more accurate information regarding the clinical effects of carbon monoxide.

In the United States and abroad the literature gives many instances of mental impairment, psychoses, and paralyses following acute gassing by carbon monoxide, and it is stated that anemia, neuritis and other symptoms follow chronic poisoning from this gas (1) (2). It undoubtedly causes more accidents, fatal and non-fatal, than any other gas in industry, and it seems important to find out how much crippling and how much loss of working time it is responsible for. Few accurate data are to be found in regard to this, and two definite problems, therefore, present themselves: (1) How frequent are late sequelae of acute carbon monoxide gassing? and (2) What effect does the gas have on men frequently exposed to small doses?

An attempt to answer these questions has been made by a survey of metal mines, coal mines, blast furnaces, and producer gas boilers and engine rooms in Montana, Colorado, Oklahoma, Arkansas, Alabama, Tennessee, Kentucky, and Pennsylvania. Data were obtained from mine hospitals, mine doctors, United States Bureau of Mines officials, superintendents, foremen, shift bosses, fire bosses, and individual miners, as well as by inspection of the less well ventilated workings and of drifts and stopes near fire areas. In a few cases red blood-cell counts were made, and in others, tests for carbon monoxide in the blood.

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In mines, exposure to carbon monoxide usually occurs in one of three ways: (*a*) after explosions or during serious fires; (*b*) about smouldering fire areas; or (*c*) after blasting. Carbon monoxide is the chief poisonous element of the miners' "white damp," "after damp," and "powder smoke." Its presence in 0.025 per cent. is sufficient to cause dizziness and severe headache; in 0.2 per cent. it is dangerous (3).

In Montana the copper mines at Butte and the smelters at Anaconda, East Helena, and Great Falls were examined. The smelters appear to present no carbon monoxide hazard under ordinary conditions. In the copper mines, the gas does occur frequently in small amounts about the fire areas and is rather troublesome. Occasionally, also, it causes headaches after blasting at certain points where the air current is not good and where two or three shifts are working. In these mines there is no record of lost time due to this cause, and only rarely is a man overcome for a few hours about the fire areas. In the coal mines, especially in the South, owing to the danger of explosions from natural gas and fine coal dust, there is always free ventilation, and the powder smoke only occasionally causes symptoms. The iron ore mines near Birmingham, Alabama, are less well ventilated and after blasting the carbon monoxide lies in the fine dust and is stirred up by the "muckers," who often have headaches from it. But there is apparently no lost time from this cause.

About the blast furnaces the gas seems to cause practically no loss of time among the men most frequently exposed to small

percentages of it — *i. e.*, the top-fillers, hot blast men, or the men tending the boilers or engines run by producer gas. Among the pipe-fitters and repair men who encounter occasional high percentages of carbon monoxide, loss of time is fairly common, but the man gassed usually lies down for a few minutes and then returns to work. Only a small proportion of these cases are sent to the hospital, and the company office has no record or even knowledge of them. In the large plants, such as those at Pittsburgh, the number of hours lost in this way must be considerable.

Acute Carbon Monoxide Poisoning

Symptoms. — The symptoms of acute carbon monoxide poisoning may vary from sudden unconsciousness without warning to merely a slight headache. The usual symptoms, in the order of their occurrence, are: dizziness or sense of fullness in the head, frontal headache, weakness of the knees, nausea, sometimes vomiting, general weakness, inability to walk or stand, and unconsciousness. The symptoms depend chiefly on the concentration (3) of carbon monoxide and on the duration of exposure, but also vary with the individual and his physical condition at the time of gassing. Often there is a stage of excitement like alcoholic intoxication. Different persons react as differently as they do to alcohol, and many men are well known to be able to stand amounts of the gas which would speedily overcome others. The most sensitive are men with pre-existing pulmonary or cardiac disease. Sudden entrance into cold air or sudden exertion causes an exacerbation of symptoms. Gastric indigestion and constipation seem to make a man temporarily more susceptible to carbon monoxide.

Sequelae. — In severe acute gassing, when unconsciousness has lasted minutes or hours, the usual after-effects are intense headache, fatigue, and muscle pains, lasting from one to three days. It is interesting that the muscle after-pains appear to be worst in those muscles most used during exposure to the gas. The temporary character of the effects of acute gassing, however, are illustrated by the following instances. In a mine disaster in Butte, Montana, twelve cases were admitted to the hospital, gassed. Nine left relieved in twenty-four hours, and the other three, two days later. No readmissions and no known sequelae occurred. In another hospital, in the past year ten miners were admitted, gassed in mine accidents. Nine went home in twenty-four hours or less. The tenth, unconscious at entry, stayed thirty-six hours. This patient had always been neurotic, a state which was accentuated after the gassing, but no new condition developed. There were no re-entries and no sequelae. The same story was told everywhere by miners, foremen, and mine doctors of many years' experience. They knew of no men permanently incapacitated through mental or physical injury from gassing. One Bureau of Mines official, however, knew of two men gassed after a coal mine dust explosion, who were mentally incapacitated some months later. It was not known what their mental or physical condition had been before being gassed. Another Bureau of Mines engineer said that two other men had been partly paralyzed after short exposure to mine gas. The history given suggested complicating disease or hysteria as the probable explanation, but no clinical details were obtained. Cases of pneumonia following gassing were rare and occurred usually when smoke or irritating gases were present.

About blast furnaces the testimony was the same — almost no late nervous or mental sequelae were known. Two cases of mental impairment were reported by company doctors, one of which occurred in a chronic alcoholic, the other, in a man who

had a strongly positive Wassermann. Concurrent disease, and especially cerebral arteriosclerosis, seems to be a very important factor in causing cerebral lesions in a person severely gassed (4). In fact, if a young, healthy adult is severely gassed by "white damp" or by blast furnace gas, he either dies in a few days or recovers entirely — a rule to which there are few exceptions.

Chronic Carbon Monoxide Poisoning

In regard to the question of chronic carbon monoxide poisoning, it was found that in certain mines about the fire areas men were exposed to "white damp" almost daily for months. While at work, these men complained of frontal headaches which sometimes lasted till they fell asleep. Next morning they felt well again unless the exposure to carbon monoxide had been unusually severe, in which case they suffered from headache and felt "all in" for a day or two. But at any time if they stopped work and stayed outdoors for a day or so, all symptoms disappeared.

Some men notice a certain degree of tolerance when working frequently in the gas. For example, a mine foreman, whom I questioned — a man 50 years old — had done mine work since he was a boy. For months at a time he had had enough gas to cause daily headaches, yet was sure that at the end of such a period he could stand more gas than he could at the beginning and more than a "green" man working beside him could stand. Tolerance to carbon monoxide has, moreover, been demonstrated experimentally by Nasmith and Graham (5), and has been noticed before in man by Haldane (6) and others. Most miners noticed neither tolerance nor cumulative ill-effects. A few veteran miners, however, thought that they had never been quite so strong since a series of severe gassings. Such a man was a fire boss who had been under tremendous strain, emotional and physical, fighting a fire for eighteen months in a coal mine. He had always been able to stand a large amount of "white damp" and had never been rendered unconscious by it, though many times men beside him had been overcome. He stated that for months after this ordeal he was nervous and his hand shaky. He believed also that his heart was affected, as he noticed palpitation and precordial distress on exertion or on entering gas, yet he admitted that, even now, he could stand as much gas as most men. This man had had no careful medical examination. The fire in question occurred thirteen years ago and he had been at work constantly ever since.

Anemia. — No evidence of anemia resulting from frequent exposure to carbon monoxide was found, either in the reports of the doctors or in red blood-cell counts. These counts and many more previously taken from Illinois blast-furnace workers show polycythemia rather than anemia. In 1911 Karasek and Apfelbach (7) examined sixty-eight steel workers. The red blood-cell counts in their cases ran between 5,500,000 and 9,600,000, two-thirds being over 6,000,000. The appearance of the red blood-cells was normal. Dr. Davis, chief surgeon of the Illinois Steel Company (8), reports that 175 red blood-cell counts taken at Gary and in South Chicago on men who had worked in the blast furnace and open hearth departments for years showed no counts below 4,000,000; 64.1 per cent. over 5,000,000; and 2.2 per cent. over 6,000,000. Physical examinations of these men showed no lesions of the nervous system.

Neurological Symptoms. — No histories were obtained from miners or mine doctors suggestive of multiple neuritis, mental deficiency, or paralysis following chronic carbon monoxide exposure. Even with illuminating gas, which has been shown to be more toxic than pure carbon monoxide (9), no serious nervous or mental results

seem to be common, at least after acute exposure. In the past two years, 134 cases of acute illuminating gas poisoning were admitted to the wards of the Boston City Hospital. Of these, not one patient has been readmitted with neurological symptoms or committed to an insane hospital unless a definite pathological condition existed prior to the gassing. This information was obtained by personal examination of the hospital records.

Tests for Carbon Monoxide in Blood. — In the mines it was difficult to find men actually suffering from carbon monoxide headaches at the moment and it was useless to examine the blood of miners for carbon monoxide after they had walked to the hospital, for they had then lost the gas through respiration. The few specimens taken in mines at the working face were negative. About blast furnaces, however, there was one situation where men inhaled carbon monoxide at intervals all through the day, and every day. These men were the top-fillers on the old style hand-filled furnaces. Blood specimens from two of such workmen out of six tested were positive for carbon monoxide hemoglobin. The tannic acid test was used (10) and the blood was taken while the men were actually at work on the furnace top. The two patients whose tests came out positive had complained of slight headache at the time the blood was taken. Some of these top-fillers had done this work for years (one for twenty years) without apparent injury to their health.

Treatment

Carbon monoxide does not form a permanent combination with hemoglobin. This has been conclusively shown by Haldane (11), Henderson (12) and others. The affinity of hemoglobin for carbon monoxide is approximately three hundred times that for oxygen, but the reaction is reversible. As soon as the man breathes oxygen or fresh air, the oxygen exactly replaces the carbon monoxide in his blood, molecule for molecule, at a speed depending on the partial pressures of the two gases in the alveoli. The red blood-corpuscles are apparently uninjured and are able to take up and transport oxygen normally as soon as the carbon monoxide has been expelled.

In the treatment of carbon monoxide poisoning, bleeding, as Haldane and Henderson have clearly stated, is harmful. Transfusion is unnecessary because under proper treatment the blood can be brought back nearly to normal within half an hour. The most recent advance in treatment has been made by Henderson (9), who advocates administering with oxygen a small percentage of carbon dioxide, to induce better pulmonary ventilation. Henderson's results are striking. In his experiments dogs were gassed thirty to forty minutes with illuminating gas in such dilution as to give 0.4 per cent. carbon monoxide, until they became completely unconscious. Untreated, these animals took approximately two hours to exhale sufficient carbon monoxide from their blood to reduce the percentage of this gas to 10 per cent. With oxygen treatment alone, this result was attained in sixty to eighty minutes; with oxygen and carbon dioxide it took only twenty minutes.

Another advance of real importance in protection against carbon monoxide is the perfecting of an efficient respirator by the U. S. Chemical Warfare Service (13). The cannister of this respirator is smaller than the army type and is effective even at zero degrees against 1 per cent. of carbon monoxide. Its life is approximately three hours. Information in regard to it can be obtained from the Director of the Bureau of Mines, Washington, D. C.

Summary

Carbon monoxide as met with in metal and coal mines and about blast furnaces in this country rarely causes late after-effects following acute severe gassing. When such effects do appear, there is evidence, almost always, of a pre-existing pathological condition.

Frequent exposure to carbon monoxide causes headache and malaise, but no evidence has been found of a cumulative harmful effect.

As was to be expected, owing to the compensating increase of hemoglobin and red cells from prolonged oxygen want (14) (15), it is possible to acquire some tolerance to carbon monoxide.

A recent advance in treatment has been made by adding carbon dioxide to the oxygen inhalations administered. Recovery is three times as rapid as when oxygen alone is used.

An efficient portable carbon monoxide respirator has been perfected by the U. S. government.

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A DISCUSSION OF THE ETIOLOGY OF SO-CALLED ANILINE TUMORS OF THE BLADDER*

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FOR the last twenty-five years the Germans have been aware that there is an undue prevalence of malignant tumors of the bladder in aniline dye workers. The first to call attention to this curious fact was Rehn (1), who presented before the German Surgical Society in 1895 the histories of three cases of malignant bladder tumor in employees of one of the great dye works, the men forming part of a force of forty-five who were employed in making fuchsin. Rehn concluded as follows:

> For the majority of bladder tumors one can only assume that compounds excreted by the kidneys and existing in solution in the urine are capable of setting up tumor formation through chemical irritation. So far these compounds have eluded our search. . . . The gases produced in the manufacture of fuchsin lead to disturbances of the urinary system, and prolonged employment over many years in the fuchsin department may cause the development of bladder tumors because of continual irritation. The harmful effects depend essentially on the inhalation of aniline fumes.

The manufacture of fuchsin consists in heating a mixture of aniline, ortho-toluidine and para-toluidine, with nitrobenzene, or ortho-nitrotoluene and para-nitrotoluene, in the presence of iron and hydrochloric acid.

This theory of Rehn's was challenged immediately, especially by Grandhomme, the chief authority on industrial poisoning in color manufacture, since he had been for many years in charge of the great plant at Hoechst-am-Main. Grandhomme admitted that aniline was irritating to the bladder mucosa, as shown in observations on men and on animals, but as to its being responsible for tumor growth, he pointed out the fact that, while Rehn had found three cases among forty-five fuchsin men exposed to aniline fumes, there were in the factory at the time about 4,000 men exposed to the fumes. Eleven years later, however, Rehn (2) was able to present to the German Surgical Society records of thirty-three cases which he had collected from German dye works, all malignant and all occurring between 1889 and 1906. To these, Seyberth added five, others three, making forty-one in all.

In 1912, Leuenberger (3) of Basel presented a paper before the same society in which he reviewed the whole subject of the occurrence and causation of bladder tumors in aniline workers and added eighteen cases from the works in Basel, which had then been running for about twenty-seven years. He specially urged physicians attached to dye works to study these tumor cases and to try to discover the substances responsible for them. The following year the German Congress of Industrial Physicians endorsed Leuenberger's request and drew up a set of questions to be answered in connection with each case of bladder tumor. This questionnaire was sent to all the German and Swiss dye works. The results of the studies made since then are now appearing in the German medical journals. Many new cases have been added to Leuenberger's list of fifty-nine, and in the last article on the subject, by Curschmann (4), the final corrected list includes 177 cases.

The statistics on which the Germans base their statement that bladder tumors

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are strikingly frequent among aniline workers are not satisfactory. They are incomplete in several respects, and it is surprising that when so much careful clinical and experimental work has been done in this field, nobody has troubled to present indisputable proof of this basic statement. We do not know how many men are exposed to fumes, and cannot tell, therefore, what proportion of the whole such a number as 177 is. The number of employees in these dye works is estimated at 80,000 to 100,000 — an estimate which is more dependable, owing to the small labor turnover, than would be a similar one in our dye works. Nassauer (5) gives the labor turnover for one of the plants in the Frankfurt region as only 15 per cent. per year. That would be more nearly the monthly turnover in an American plant. During the war, however, there must have been a great deal of shifting; indeed, Nassauer speaks of the introduction of women workers and speculates as to the probable appearance of bladder tumors among them during the next twenty years.

The exact number of men exposed to what is regarded as the exciting cause of tumor growth is not the only missing link in the train of reasoning on which the Germans base their statement that dye workers have more than their due proportion of bladder tumors. The figures given by Rehn for the Frankfurt region are as follows: Between 1895 and 1918 there were 92 cases of bladder tumor in the City Hospital, 22 of which were unquestionably caused by aniline and 24 possibly so caused, making 46 or 50 per cent. of the whole number. The proof would be much more convincing if the records showed what proportion of the male population of the hospital was employed in the dye works. The same criticism applies to Leuenberger's figures from the Basel hospital, which cover fifty years. (See Table 1.) Nassauer's plant (5) had 32 cases in twenty years, with a working force of 105 men and an annual turnover of about 15 per cent. This is really the most striking record offered in the literature, but Oppenheimer (6) believes that the proportion is higher than that given in any official report. According to the tales of his patients there was one factory with 60 men in which during twelve years 15 cases appeared; in another with 60 men there were 27 cases,

TABLE 1. — CASES OF BLADDER TUMOR IN BASEL HOSPITAL, 1861–1910

Years	Number of Male Patients	Number of Cases of Bladder Tumor		
		In Hospital	In Color Makers	In Dyers
1861–1870	2600	1	0	0
1871–1880	3450	0	0	0
1881–1890*	4250	1	0	0
1891–1900	5500	4	0	0
1901–1910	9650	16	10	2

* The dye industry began in Basel in 1885.

9 of which were known to have been fatal; and in a third, 29 out of 30 men died of bladder disease in ten years' time.

A typical history of the earlier cases of bladder tumor reads as follows: The man comes to the plant doctor for treatment usually because he has noticed blood in the urine. Cystoscopic examination * then reveals a papillomatous growth, more rarely a flat carcinoma with a broad base. In more recent years, since physicians have been on the watch for these tumors, the examination is often made before the appearance of blood and discloses sometimes only a cystitis, with ulceration perhaps, then later on, even if the man is removed from contact with aniline, a new growth is found. Different varieties are described — pediculated papilloma, villous polypus, wart-like excrescences, or general papillomatosis of the whole bladder. These benign growths may undergo carcinoma-

* The use of the electric cystoscope was first introduced in 1880 in Germany by Nitze, and undoubtedly as its use extended many early cases of tumors were discovered which formerly would have gone undetected.

tous degeneration, but there are also malignant growths which are quite different in appearance and which apparently have not passed through the papillomatous stage, being solid, with a broad base (6). In some instances, a small fresh polyp can be seen on one side of the bladder, and a carcinoma on the other. The cancerous growth may invade the neighboring lymph glands or the ureter and kidney, as in one of Rehn's cases, or the bones of the pelvis and the lower abdominal wall, as in a case seen by Czerny. Only one autopsied case has shown metastases in liver and lungs. In the earlier cases, it was said that the seat of predilection was near the mouths of the ureters, but later reports showed that they might be situated in any part of the bladder.

A long exposure to the chemical which is the exciting cause seems to be necessary. The statistics from Hoechst, Ludwigshafen, and Greppin (7) show that the cases developing in the fuchsin department were in men who had been employed on an average from twelve years in Greppin to nineteen in Ludwigshafen. Those who worked in the benzidine-naphthionic department had had a shorter period of exposure, averaging five years in Ludwigshafen, and six years in Greppin. Oppenheimer's patients had worked from two to twenty-eight years, averaging eighteen years. The two-year case, which was far below the average — indeed, the shortest exposure on record so far — occurred in a man who worked in the benzidine department.

Both Curschmann and Oppenheimer find that there is no connection between the length of exposure and the malignant character of the growth, nor is there any relation between the particular compound causing the tumor and the character of the tumor. Oppenheimer observed six men who had worked together in the same room for twenty years; two were healthy, two had been operated on for bladder tumor and had recovered, and the last two had died from bladder tumor. Of Curschmann's twenty-six cases, one developed after five years, six after five to ten years, six after fifteen to thirty years, and thirteen after more than thirty years' employment. The Basel cases did not begin to appear till the industry was 16 to 17 years old, and in England the only dye works in which information about bladder tumors among the men can be obtained is the oldest one, more than 20 years old. Curschmann finds the great majority of cases of cystitis among dye workers as reported in the literature occurring after 40 years of age. Oppenheimer's twenty patients were between 34 and 47 years of age, decidedly younger than the average for bladder tumors in general.

The histories of color makers who suffer from bladder tumors show that ordinary aniline poisoning has nothing to do with the condition in the bladder. A man may have had repeated attacks of acute aniline poisoning or the chronic form of poisoning, yet never have even a cystitis; or he may never have had typical aniline poisoning and yet develop a tumor of the bladder.

One very interesting feature of this variety of bladder tumor was brought out by Leuenberger and confirmed by Schwerin (7) and by Oppenheimer — namely, the fact that the tumor may develop long after the exposure to the exciting cause has ceased. Leuenberger tells of a man who worked in benzidine for seven years, had cystitis, and was transferred to another department where he worked for two years. He then left the factory, and two years later blood appeared in the urine and he was operated on for tumor of the bladder. Schwerin of Hoechst reports two similar cases: one, a man who worked five years in the benzidine-naphthionic department and twenty-three years later had tumor of the bladder; the other, a man who worked eleven years in aniline and eight years after

leaving the factory had a tumor removed from the bladder. Oppenheimer saw tumors develop ten years and seventeen years after the men had left the factory.

It seems from the observations of Nassauer and of Oppenheimer that an extremely slight exposure to the exciting cause is sufficient. Oppenheimer had three cases which developed in men who never came in contact with the chemicals, but who worked in rooms adjoining the process departments. These cases were slow, the tumors developing after twenty to twenty-six years. Several of Nassauer's patients were employed in departments in which no manufacturing was carried on but which were next to the departments making benzidine.

In the search for the exact compound or compounds which are responsible, a careful study has been made of the history of each case so far reported, in order to see which of the intermediates used in color manufacture seem to be connected with bladder tumors. A great variety of compounds emerge as probable agents, compounds with different degrees of toxicity and with different physical and chemical properties, but with this feature in common, that they are all amido compounds, containing the radical NH_2, produced by the reduction of nitro compounds. The latter, though distinctly more toxic than the amido group, do not have this peculiar effect. These are the lists which have been submitted:

List from Hoechst-am-Main (7)

Naphthylamines	30 cases
Benzidine and naphthionic acid	28 "
Fuchsin	21 "
Aniline	8 "
Black and blue colors	4 "

Curschmann's List (4)

Beta-naphthylamine	10 cases
Aniline	5 "
Fuchsin	3 "
Benzidine-naphthionic	3 "
Other bases	3 "
Blue colors	4 "

Oppenheimer's List (6)

Aniline	3 cases
Aniline colors	2 "
Benzidine	5 "
Aniline-naphthylamines	3 "
Aniline-benzene-toluene	1 "
Benzidine-aniline	1 "
Benzidine-tolidin	1 "
Amido-naphthol-cresoldicarbonic acid	1 "
Naphthylamine-cresoldicarbonic acid	3 "
Not directly exposed	1 "

Nassauer gives the following substances in connection with which bladder tumors have appeared: aniline, para-toluidine, xylidines, cumidins, naphthylamines, fuchsin, benzidine, tolidin, and blue rosaniline coloring matters made from fuchsin by the action of aniline in the presence of acetic or benzoic acid.

In trying to determine which of these compounds is the responsible agent, there are several difficulties which must be borne in mind — difficulties encountered more or less in every study of industrial poisoning, but especially in connection with such complicated processes as those of dye manufacture. In the first place, every process involves the use and production of more than one compound, so that even if a man is engaged in only one process it cannot be said that he is exposed to only one poison. Moreover, it is very common to have two distinct processes going on in the same room, so that the workmen are exposed to other compounds than those with which they are working. The benzidine-naphthionic department, mentioned so often in connection with bladder tumors, is one in which Congo red is manufactured from benzidine, which is a product of nitrobenzene, and from naphthionic acid, which is a product of alpha-naphthylamine. The harmful substance here has sometimes been considered benzidine, sometimes alpha-naphthylamine — neither of which is markedly toxic — while Nassauer believes

that it is the small percentage of aniline accidentally formed in the conversion of nitrobenzene to benzidine. Nor must it be forgotten that certain poisonous substances may be formed accidentally in the course of industrial processes, and their presence not suspected, as when hydrogen sulphide is given off in the making of sulphur dyes, or hydrogen arsenide in various reduction processes.

Industrial conditions bring about other difficulties which are especially evident when the form of poisoning to be studied is very slow, drawn-out over a great many years. Workmen change from one department to another, and each change brings new compounds into question, or they go from one factory to another, in which the processes are different. It is also true that the same compound used in different processes may be attended with very different degrees of danger. Thus, it is said that in the making of benzidine there may be more actual exposure to aniline vapor than in the manufacture of aniline itself.

These difficulties strike one forcibly when one tries to bring into some sort of harmony the results of the studies in the different German factories. For instance, Nassauer believes that all the cases in the literature can be traced to one department — the manufacture of benzidine. He has been very strongly impressed by the dangers in benzidine manufacture, but then, it is obvious that the plant with which he is connected makes benzidine chiefly, producing before the war 60 to 70 per cent. of the world's supply. It is easy to understand, therefore, why he finds that every one of the thirty-two cases which occurred there were in men who had been working in or near or outside of the benzidine rooms. Curschmann of Hoechst and Engel (8) of Ludwigshafen find a singularly large number of cases in men exposed to beta-naphthylamine, but Nassauer insists that this compound could not be responsible since he has never seen a case of hematuria or strangury in a naphthylamine worker in twenty years, and he believes that there are other fumes in the naphthylamine departments.*

The Hoechst investigators, Schwerin (7) and Kuchenbecker (9), agree with Nassauer that the greater number of cases come from the benzidine-naphthionic department. They do not attribute this to aniline fumes, however, but to benzidine dust. The earlier reports of bladder tumors placed the danger in the fuchsin department. Aniline began to be used on a large scale for the manufacture of fuchsin in 1872 and about twenty years later the reports of bladder tumors in aniline workers began to appear. But aniline is not the only compound used in fuchsin manufacture; ortho-toluidine and para-toluidine must also be considered.

The causation of these tumors is a subject at present occupying most of the attention of the German investigators, for obviously it is a matter not only of scientific but of practical importance, as no efficient system of prevention can be devised until the dangerous substances are discovered. Experiments on animals have so far cast very little light on the subject. It has been known for a long time that irritation of the bladder could be produced by injection of aniline and some of its homologues, and such dye intermediates as tolylenediamine, phenylenediamine, and paranitraniline will set up not only irritation of the bladder mucosa but also hemorrhage. As soon as the administration of the poison is suspended, however, the symptoms subside, nothing further occurs, and the bladder mucosa becomes quite normal again. Nor are these particular com-

* Hematuria and strangury have been reported, however, in connection with beta-naphthylamine by German factory inspectors and in the one American factory where I have seen it used it has been found decidedly more toxic than alpha-naphthylamine, causing frequent, burning micturition, as if the urine were over-acid, as Engel has found it to be in dogs which have been fed beta-naphthylamine.

pounds connected with cases of bladder tumor in dye workers. Oppenheimer tried to produce tumors in animals by repeated injections of benzidine and tolidin in suspension, but although he continued his experiments for eighteen months, there was absolutely no result.

Leuenberger recalls the work done on aniline excretion in Schmiedeberg's laboratory (10), which showed that aniline undergoes in the body hydroxylation to para-amidophenol and is excreted in the urine in conjugation with ethyl sulphuric acid. He maintains that it is this hydroxyl derivative of aniline and similar bodies which sets up proliferative processes in the whole urinary tract: first, inflammatory infiltration and atypical proliferation of the mucosa, then, papilloma formation, granuloma, carcinoma, sarcoma, and mixed forms. He assumes a precancerous stage of inflammation and proliferation, such as occurs in arsenical granuloma and epithelioma, in X-ray lesions, and in the so-called pitch cancer. The late development of the tumors he explains by the fixation in the body of decomposition products of the poisons, with continual damage to the bladder cells, or the effect of the chemical may be passed on through successive generations of cells. He points out the similarity between these aniline tumors, which are clearly caused by some chemical irritant, and other growths which are known to be the result of chemical irritants, such as the cancer of chimney sweeps so thoroughly studied by the English, and the cancer of briquette makers first reported by Volkmann, then by the English, in all of which there is, first, irritation of the skin, then, the formation of warts, or nodules, or sclerodermatous patches. If the man leaves work, nothing more serious may occur, but if his exposure is prolonged, slow carcinomatous degeneration sets in.

Nassauer also compares aniline workers' tumors to the pitch and tar cancers described by the English, and he speaks of a curious observation made among the miners of cobalt arsenide ore in the Saxon Erzgebirge, who were found to have an enormous incidence of lung carcinoma. As for the ability of aniline and similar bodies to set up proliferative changes in the bladder mucosa, there seems to be only one observation. Fischer (11) found that epithelial growth was stimulated by the injection of certain fat-soluble colors in oil. "Scharlach Roth" (amidoazotoluene) was the most active and has since been used to encourage healing after extensive burns.

Oppenheimer believes that there is a biological affinity of these poisons (benzidine, aniline, naphthylamines, tolidin, etc.) for the epithelium of the excretory part of the urinary system. The kidneys are not involved but the bladder is affected. He suggests that perhaps more than one substance is responsible, one sensitizing the tissue to the action of the other. The length of exposure to the exciting cause seems to be a matter of no importance. Oppenheimer agrees with Nassauer that a short exposure may set up the process which eventuates in a tumor. It is plain that the "revolution" in the tissue once begun keeps on after the cause is removed, *cessante causa non cessat morbus.*

According to Nassauer the irritative substance is always aniline, mixed with air. The condition is always produced by fumes, containing a quantity of aniline which is too small to set up clinical symptoms of intoxication, but which, dissolved in the moisture of the alveoli of the lungs (aniline is 3 per cent. soluble in water), penetrates the cells and reaches the lymph stream or the blood. A very dilute mixture of aniline with air, such as is breathed by men working in a room next to the one containing the source of aniline fumes, causes a more rapid tumor growth than does a larger quantity of aniline in the air, and the men who work out of doors, get-

ting only minute quantities of fumes from the nearby building, have an even shorter latent period. Nassauer considers the action of aniline so powerful that one year's exposure to the fumes is too long, and since 1904, in the factory under his charge, he has permitted only three months' employment in the benzidine department — in his opinion, the danger spot.

Leuenberger suggested that, since the amido compounds which seem to be responsible for tumor growth undergo hydrolysis in the body, it should be possible to ascertain which of the amido compounds used in the dye industry are eliminated in this particular form, as para-amidophenol, and then to check up the clinical cases and see whether they could be linked up with these compounds. To this Engel replies that there are several compounds apparently associated with tumor formation which do not undergo hydrolysis in the body and appear in the urine as para-amidophenol. For instance, para-toluidine is excreted unchanged, as is also alpha-naphthylamine, while diphenylamine undergoes a complete loss of the amido group.

Kuchenbecker also undertook to test this statement of Leuenberger's. Since a hydroxyl amido compound, containing as it does a free amido group, can be diazotized in acid solution with a nitrite and produce an azo color, it is comparatively simple to prove its presence. If aniline is administered to animals, a red azo color can be obtained in the urine, and the same result is obtained with ortho-toluidine, but not with para-toluidine. This is because aromatic amido compounds undergo such a change only if the para position is free, but not if it is occupied, as it is in para-toluidine. Kuchenbecker then fed benzidine to dogs and found a substance in the urine which was not a hydroxyl compound, nor was it benzidine. Practically the same result was obtained with tolidin. Alpha-naphthylamine is excreted unchanged and gives typical reactions with beta-naphthol. Beta-naphthylamine is also excreted unchanged. It seems impossible, therefore, that para-amidophenol should be responsible for the occurrence of bladder tumors, since all the last-named substances are apparently as much concerned in their causation as is aniline.

At present, Engel is conducting experiments with beta-naphthylamine, which apparently has been connected with a large number of tumors — an especially singular fact because it is not particularly volatile, and does not cause much ordinary industrial poisoning, and because there is nothing in the work that brings about unusual exposure. Engel wishes to discover whether beta-naphthylamine undergoes hydroxylation and, if so, whether amido-naphthol is formed or amido-dioxynaphthalene, and whether these are eliminated in conjugation with ethyl sulphuric acid or with glycuronic acid. So far he has been able to prove that after the administration of beta-naphthylamine to dogs, both acids are increased in the urine. If the animal is on a meat diet, it is the ethyl sulphuric acid which shows a marked increase; if on a carbohydrate diet, the glycuronic acid.

There the matter rests at present; the problem is no nearer solution than that. There is one compound, however, which must be considered as having a possible bearing on the occurrence of bladder tumors in dye workers and which is not mentioned by the German investigators — namely, hydrogen arsenide. The danger of arsenical poisoning in fuchsin manufacture was well known in the early days of the industry, for arsenious acid was one of the compounds used for oxidation in making fuchsin, as nitrobenzene is now. That method was discontinued about thirty years ago, but it is recognized in German dye works that accidental arsenical poisoning may still occur from an evolution of hydrogen arsenide not only in fuchsin

manufacture but in all processes where acid and metal are brought together and one of them is contaminated with arsenic. The chamber sulphuric acid of commerce, made from iron pyrites, is frequently thus contaminated, as is the hydrochloric acid made by the action of such sulphuric acid on sodium chloride, while both the iron scrap and the zinc dust used in reduction processes in the making of intermediates and colors may also carry arsenic as an impurity, the zinc dust especially. German dye works are so well guarded against the escape of fumes of all sorts that accidental poisoning of this kind is now decidedly rare, yet that it can occur is shown by the history of one of Nassauer's patients who suffered from hydrogen arsenide poisoning while making benzidine.

It is in the process of reduction that this danger is found. Two forms of reduction are used in the manufacture of intermediates, acid and alkaline or neutral. Nitrobenzene, subjected to acid reduction by nascent hydrogen from iron filings and hydrochloric acid, yields aniline. Nitrotoluene yields ortho-toluidine and para-toluidine. If either the iron or the acid contains arsenic as an impurity, hydrogen arsenide may form in the course of reduction, but in a well-managed plant this reaction is carried on in tightly closed autoclaves, and there is very little, if any, escape of fumes. However, when, in going through a very excellent German plant, I commented on the arrangements for fume removal in the aniline reduction room, I was told that the rule there was to allow no vapors of any sort to escape into the room because of the ever-present possibility of traces of arseniuretted hydrogen. Of course, if the apparatus is not perfect it will get out of order and men must go in and clean out the sludge and make repairs. Five mild cases of arsenical poisoning occurred in a British dye works from this source, but were recognized as such only because arsenic was found in the urine. Tests for arsenic are not made in American dye works and if such cases occur they are not recognized but are diagnosed as aniline or toluidine poisoning.

Alkaline reduction, used to produce benzidine and tolidin, is attended with much more danger of arsine poisoning than is acid reduction. Briefly, the process is as follows. Nitrobenzene, treated with zinc dust and sodium hydrate, is reduced first to azoxybenzene, then to azobenzene, and then to hydrazobenzene, which forms colorless crystals. At this point it is customary in Germany and in England to add hydrochloric acid, in order to form soluble zinc chloride, and get rid of the zinc by filtration. The temperature must be kept down by means of ice, or brine coils, because benzidine will form if it is warm and will be lost with the filtrate. In the summer of 1918 five cases of severe arsine poisoning with two deaths occurred in a British dye works where, in order to keep down the temperature of the hydrazobenzene-zinc-hydrochloric acid mixture, the reducer was opened and a chunk of ice dropped in. The fumes of arsine escaped from the opening and poisoned the nearest workmen. Five cases of severe poisoning with one death were caused in a New Jersey plant by the fumes rising from an uncovered tub containing hydrazobenzene made by this same method of alkaline reduction and evidently with arseniferous zinc. It was when the hydrochloric acid was added and the temperature raised to bring about the next stage, the molecular change of hydrazobenzene into benzidine, that the tub "boiled up," as the men said, and the five nearest it were overcome with the fumes — three very seriously, one fatally.

Dr. T. H. Wignall (12) of Manchester, who is connected with a large dye works, has made a very interesting study of the occurrence of arsenical hematuria in benzi-

dine makers and in workers in certain other reduction processes. His attention was called to the possibility of mild arsenical poisoning by a fatal case of jaundice in a benzidine worker, which did not come under his observation early enough to allow him to establish the presence of arsenic. He began then to have a quantitative test made for arsenic whenever the urine of an employee showed a color as deep as porter. When this occurred, not only was the urine of the man himself examined for arsenic but also specimens from all the other workers employed on the same process. The tests were carried out by Delépine of the Public Health Laboratory of Manchester. Wignall found that the tolerance to arsenic in cases of this sort was much greater than it is generally stated to be. Men whose urines are deeply colored, and contain albumin, blood pigment, and casts, may not consider themselves sick at all and may not even be jaundiced. Examination of those who do complain shows symptoms which might easily be attributed to aniline or to some similar compound. These symptoms are palor, slight icterus, rapid feeble pulse, languor, loss of appetite. Hospital treatment in Wignall's cases was always successful and there were no sequelae and no neuritis. It is evident that such cases might easily go unrecognized for years, especially as the absorption of arsenic would never be uninterrupted, and there would always be periods during which the air was uncontaminated and the man's system had time to rid itself of the absorbed arsenic. The histories of Wignall's cases show that in about four to eight weeks the arsenic has practically disappeared from the urine. The essential facts in his five cases are as follows:

Case 1. — Icterus, weakness; urine the color of dark porter, with methemoglobin and casts; 0.796 mg. arsenious acid per 100 c.c. urine on Nov. 14; on Dec. 12, less than 0.01 mg. and only a trace of albumin.

Case 2. — Porter colored urine with 0.035 mg. arsenious acid per 100 c.c. urine on Nov. 9; on Dec. 20, less than 0.01 mg.

Case 3. — Urine black, sp. gr. 1025, albumin; 0.2 mg. arsenious acid on Dec. 5; less than 0.01 mg. on Jan. 30.

Case 4. — Abdominal pain, vomiting, icterus; urine deep Burgundy red, clear, sp. gr. 1025, acid, much albumin, methemoglobin, and oxyhemoglobin; 0.185 mg. arsenious acid on Jan. 24; less than 0.01 mg. on Feb. 26.

Case 5. — No pain or icterus; urine dark brown, considerable amount of albumin, sp. gr. 1009; 0.07 mg. arsenious acid on Feb. 13; less than 0.01 on Feb. 27.

Cases of mild arsenical poisoning have developed in English plants, I am told, in cleaning out an aniline reducer, and in filtering off the zinc chloride from hydrazobenzene in benzidine production. The only cases on record in American dye works are the five given above. In our large dye works benzidine production is not attended with this risk, for the hydrazobenzene crystals are caught in a fine screen and the zinc dust filters through and is used again.

If one examines the histories of the German cases of aniline tumor in the light of this theory, that arseniuretted hydrogen may be the causative agent, not any aromatic compound, several features emerge that seem to strengthen it.

In the first place, all the products which have been held responsible for these tumors are reduction products, formed by nascent hydrogen acting on a nitro compound.* As we have seen above, such

* For beta-naphthylamine this is not true. It is made, not by a reduction process, but by treating beta-naphthol with ammonia water. The only explanation I can suggest for the occurrence of tumors in this department is one based on the conditions in the one American factory where I have seen it made. Here in the beta-naphthylamine department, naphthylamine-sulphonic acids are made by the reduction of nitronaphthalene-sulphonic acids, and the reducing agents used are scrap iron and chamber sulphuric acid. At the time of my visit, an escape of fumes directly after reduction was very evident. One would have to know just what processes were carried on in or near the beta-naphthylamine departments in the German factories where this has seemed the danger spot, before one could decide the question whether there was or was not a possible source of hydrogen arsenide fumes there.

reduction is carried on by means of hydrochloric acid or sulphuric acid with scrap iron or zinc dust exactly as if one were making Marsh's test for arsenic. The compounds produced by alkaline reduction with subsequent treatment of the zinc dust with hydrochloric acid seem to be more productive of bladder tumors than those produced by acid reduction, and we have seen that there is more danger of escape of hydrogen arsenide fumes in alkaline reduction than in acid reduction. The benzidine department is the one in which the largest number of cases are at present appearing. Nassauer attributed his entire twenty-eight cases to the fumes from benzidine manufacture. A significant case related by him is that of a woman — the wife of one of the workmen — who did not work in the plant but lived in a room next to the one in which benzidine was prepared. She and her husband both had tumor of the bladder. It is shown in the statistics from Hoechst and from Greppin that benzidine men have a shorter period of exposure before the development of tumors than do fuchsin men (6), and the one of Oppenheimer's cases that developed most rapidly was in a benzidine worker.

That long continued absorption of small quantities of arsenic may result in the formation of epithelial growths, benign and malignant, was established by Jonathan Hutchinson and confirmed by dermatologists in America, Germany, and France. In discussing the chemical bodies which have the property of stimulating new growth, Leuenberger places arsenic at the head of the list. Nutt, Beattie, and Pye-Smith (13) have recently collected such cases from the literature and have added another. Thirty-one cases make up their list, in three of which, however, the administration of arsenic was not proved. Two were industrial in origin; the men had been working for years in a factory making sheep-dip with white arsenic. Three were caused by drinking water contaminated with arsenic in the Reichenstein epidemic described by von Geyer before the International Congress of Medicine, Paris, 1900, and twenty-three were attributed to the action of repeated doses of arsenic administered as a medicine for many years, usually for some skin disease, but in three instances for constitutional disturbances. In one instance, the lesions developed some years after discontinuance of the arsenic. Dubreuilh in 1910 described four cases of arsenical keratoma, one of which underwent carcinomatous degeneration.

The Germans have commented frequently on the analogy between aniline tumors and those caused by soot, pitch, and paraffin. Leuenberger and Nassauer have already been quoted to this effect, and it is significant to note in this connection the findings of the British Royal Commission on Arsenical Poisoning, with regard to arsenic in coal. Delépine found by analysis 5.8 grains of arsenious acid, As_2O_3, per pound of coal in one specimen, and 28 grains in another. The epidemic of arsenical poisoning from beer in Halifax in 1902 was traced to drying the malt in air heated by burning coal which contained arsenic.

Even more significant is a recent study made in Belgium of briquette makers' cancer, which the authors attribute to arsenic present in the coal. Bayet and Slosse (14) found in one briquette factory three men with skin cancer out of a force of only thirteen men, and later two more cases developed. Inquiry revealed a history of warty growths in six more, so that eleven out of thirteen men had skin lesions. These were not typical keratomatous plaques on soles and palms, as described by Jonathan Hutchinson in arsenical cancer, but carcinomatous degeneration of warty growths. The likeness to arsenical cancer was seen, however, in the fact that the cancers were multiple and developed fairly

early in life. There was also an extraordinarily large number of scrotal lesions, as in chimney-sweeps' cancer. Except for soot cancers this is a very rare location, only one among 2,400 malignant tumors in males in the Vienna General Hospital occurring there. The final proof that arsenic was the cause of the lesions was furnished by the detection of arsenic not only in the coal, soot, dust, and briquette mixture, but in the urine, hair, and finger nails of the workmen. Control tests made in the villages among other workmen gave negative results. Bayet and Slosse would attribute also to arsenic in coal the English cases of chimney-sweeps' cancer and the epithelioma of English briquette makers.

Finally, an analogy has also been drawn between aniline tumors, caused apparently by some chemical irritant, and the lung carcinoma of cobalt arsenide ore miners. The occurrence of malignant lung tumors among the miners of the Schneeberger cobalt mines in Saxon Switzerland, which was brought to light as long ago as 1878, has not aroused as much curiosity among German pathologists as one would have expected. A tumor described by Härting and Hesse (15) in 1878 was examined by Weigert and pronounced by him to be lymphosarcoma, originating in the bronchial lymph glands. Härting and Hesse stated that 75 per cent. of the cobalt miners died of malignant lung tumor, and they believed the cause was the arsenic of the ore, which consists of cobalt arsenide, nickel, and bismuth. Nothing more seems to have been heard on the subject till 1884, when Ancke (16) reported a second case of lymphosarcoma of the lung. In 1913, Arnstein (17) reviewed the whole subject, and found that 44 per cent. of the deaths among Schneeberger miners were attributed by the physicians of the region to malignant tumor of the lungs, but that the diagnoses were not based on autopsy. He examined seventy miners and found physical signs of lung disease in about half; especially indicative of lung sarcoma was the parasternal and paravertebral dullness. He could secure material for only two autopsies, and one of these proved to be caseating tuberculosis, but the other was a malignant tumor — squamous celled carcinoma — originating in the right lung and with extension to pleura and pericardium, and with metastases resembling lymphosarcoma in lymph glands, liver, and spleen. He found that Schmorl of Dresden had had two cases of round-celled sarcoma of the lungs in Schneeberger miners in recent years, and one case of squamous celled carcinoma.

In view of the proof that chronic arsenical poisoning is capable of producing a continual irritation which gradually results in cell proliferation, benign or malignant, and since the possibility of hydrogen arsenide poisoning is admittedly present in all the processes with which the bladder tumors of aniline workers have been associated, it seems fair to insist that hydrogen arsenide is a possible cause which must be considered. There is no such proof of the power of amido compounds to cause tissue proliferation.

If this explanation is proved true by quantitative tests for arsenic in the urine of men employed in dangerous departments, it will greatly simplify the problem. Instead of a multitude of compounds any one or all of which may be the sought-for cause of bladder tumors we shall have one only, a compound not constantly present in any process with which these tumors have been connected, but probably present from time to time in every one of them. It will explain certain puzzling features of the problem; such, for instance, as the fact that it is only the production of aniline or benzidine that gives rise to tumors, not their subsequent use as intermediates. As Grandhomme pointed out in his controversy with Rehn, there is no reason why

aniline fumes should cause tumors in the men in the fuchsin department and not in the other 4,000 men exposed to aniline in the rest of the plant. It is also singular that, after years of extensive use of aniline in rubber compounding and in reclaiming rubber in Germany, bladder tumors have not appeared as an occupational disease among rubber workers.

It is quite true that no case of bladder tumor has so far been traced to slow absorption of arsenic. The cases of cancer following prolonged administration of arsenic have been in the skin. Whether the difference in the method of administration, by inhalation of minute quantities, instead of by ingestion, would account for the difference in location of the lesions can be only a matter of speculation, as is indeed this whole discussion. Nor is it a speculation to which American industrial physicians can contribute anything positive as yet, for the making of dyes and dye intermediates is too recent in this country to lead us to expect the appearance of bladder tumors among the workmen for some years, if indeed the excessive labor turnover in this industry does not serve to protect them against it altogether. For the final acceptance or rejection of this suggestion as to the etiology of bladder tumors in color workers we must look to the Germans.

Summary

The case for hydrogen arsenide as the cause of bladder tumors in aniline dye workers may be summed up as follows.

1. The substances, with the exception of beta-naphthylamine, which have been connected with tumor formation are all reduction (NH_2) compounds, formed by reactions in which the accidental production of fumes of hydrogen arsenide is an ever-present possibility, and the processes in which this danger is greatest are those noted as responsible for large numbers of tumor cases. Even in the best constructed plants minute quantities of the gas may escape, especially in the course of filtration or of cleaning or flushing out the apparatus. It seems far more reasonable to attribute such a slow toxic action to small quantities of hydrogen arsenide than to high dilutions of aniline vapors or to benzidine dust.

2. No aromatic compound thus far studied has been indisputably proved as the cause even of the cystitis which precedes tumor formation, and none connected with clinical cases of bladder tumor has been shown to be capable of setting up proliferative growth.

3. Arsenic absorbed from the fumes produced by reduction processes is excreted by the kidneys, and has been recovered from the urine. Since, then, arsenic is known to be capable of exciting epithelial proliferation in other parts of the body, it seems possible that the same effect may be produced when it acts on the mucosa of the bladder.

4. The resemblance between arsenical cancer and aniline tumors becomes plain when we study the literature of arsenical cancer caused by long continued internal administration of small quantities of arsenic as medicine or in drinking water, or caused by arsenic in soot and pitch, or by arsenic in cobalt ores. In all these growths, as in aniline tumors of the bladder, there is a precancerous stage of irritation, of epithelial cell proliferation, then tumor formation, and then slow carcinomatous degeneration. The whole process takes years, but the age at which the cancers develop is earlier than the average age for ordinary cancers. The growths are likely to be multiple, and, in the case of the skin cancers caused by administration of arsenic, the cancer may appear some years after the drug has been discontinued. The same phenomena have all been noted in cases of aniline tumor of the bladder.

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HEALTH IN MERCANTILE ESTABLISHMENTS
III. COMMON SANITARY DEFECTS IN STORES*

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A RECENT hygienic survey by the author of a number of large stores has disclosed certain sanitary defects which influence the health and productiveness of the workers. This paper discusses briefly the most common of these defects and suggests remedies for them. In the investigation in question it was encouraging to find that several of the newer stores were almost perfect in mechanical construction and functioning and that some of the firms occupying old buildings had spared no expense in improving the health conditions of their plants. In many of the stores the managements had made intelligent provision for the comfort of their employees not only while at work but also when off duty at noon.

Problems Affecting Health and Comfort of Workers

Locker Rooms. — Separate locker rooms for men and women, with convenient wash rooms and toilets, require considerable space and equipment. The most common as well as the most satisfactory arrangement is to have metal lockers set in rows on a concrete floor in a well-lighted and well-ventilated basement. In a large store the locker room usually requires an attendant to insure cleanliness, proper lighting, and ventilation, and to prevent abuses, such as the storage of perishable food, the strewing of waste, pilfering, and the loss of time from unnecessarily prolonged personal toilet. A careful inspection system is always necessary. Rigid rules should be made to prevent the insanitary practice of keeping clothing elsewhere in the store, especially if food is to be handled. To overcome the evil of storing perishable food in locker rooms an employees' bundle room should be provided.

Lunch Rooms. — The noon lunch, so important to the worker's health and vigor, is a problem which has been studied and solved by many stores. It is essential that hot, nutritious food in sufficient variety be supplied as nearly at cost as possible, and that this food be served in congenial surroundings, where there is opportunity for rest and recreation.

The employees' lunch rooms at present provided grade from the lunch room equipped with tables and chairs for the use of employees who bring their own food, to the modern cafeteria which is presided over by a trained dietitian, and which supplies an excellent variety of food at cost. In every store there are always some workers who must practise strict economy because of dependents at home, and who are consequently apt to be undernourished. It is to the interest of the store that these employees receive substantial luncheon. In some cases this situation has been met by providing at very low rates simple, substantial food, such as milk, cocoa, bread and butter. Education in regard to a balanced diet is much needed. The appeal to the individual may be made on the score of both health and economy.

Recreation. — Suitable recreation at the noon hour is second in importance only to nourishing food. Good music provides relaxation more quickly and for a larger group of people than any other single means. To some of the more youthful and

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more energetic workers dancing is an enjoyable recreation; to others, who prefer to read, a store branch of the public library is very acceptable. To still others, in seasonable weather, a walk in the open air gives the needed noon recreation.

The matter of recreation outside of store hours is an important subject, although at first it may seem to be beyond the circle of store influence. Studies are available to show that many shop girls and other workers lack suitable opportunities for necessary recreation and that this lack of diversion not only influences markedly their productiveness but also may result in frequent change of occupation. The employment office may some day add to its blank another heading — namely, *Avocation*. On the answer to this question often depends the likelihood of stability; a good avocation favors a settled vocation. Already many stores have, unconsciously perhaps, recognized the importance of recreation outside of work hours and have organized clubs, athletic teams, bowling teams, and theatre parties. Some stores have vacation or rest houses, which serve as preventoria for those physically below normal, and as clubhouses for social week-end parties. Such adventures in friendship have proved acceptable and successful.

Drinking Water. — The individual drinking glass which frequently becomes a common drinking cup should be replaced by paper cups or bubble fountains. To be sanitary, however, a bubble fountain should be so arranged that the stream of water does not fall back on the source and that the lips do not touch the source.

Washrooms and Toilets. — White enamel paint is a great aid in insuring cleanliness in washrooms and toilets. The rooms should, moreover, be sufficiently well lighted to avoid the possibility of dirty corners and should be supplied with some sort of waste bucket, preferably with an automatic closing top. Some stores have found it necessary, especially in public toilets, to have fixtures which cannot be blocked by waste.

The matter of providing towels involves considerable expense and has not as yet been entirely solved. Paper towels are hygienic but not altogether satisfactory. Individual cloth towels are expensive to buy, require laundering and much handling, and are too often shared with others. From a sanitary standpoint the electric hot air drier, which is being tried in many stores, is very satisfactory. It can be installed for $98 and furnishes a hundred dries for 7 cents. No figures are available on repairs and upkeep. The chief objections to this machine are that it is noisy and generally requires from forty to fifty seconds to dry the hands thoroughly — about double the usual time with a cloth towel.

Common Causes of Fatigue. — For members of the clerical force, who usually sit all day at the same desk, working conditions should be made as favorable as possible to reduce fatigue. Offices should be well ventilated without noticeable draft, and should not be too warm. The best *temperature* for these rooms is 68°. Higher temperatures produce a gradual strain leading to fatigue and lower temperatures, especially below 65°, are apt to be uncomfortably cool.

The *lighting* is the next most important consideration. Daylight in sufficient quantity is, of course, the best. If artificial light is necessary, indirect or reflected light from a favorable ceiling or diffused light from ground glass or porcelain globes is very satisfactory. The individual adjustable shaded light is best adapted for certain kinds of close work. It should be so arranged that the light falls over the worker's left shoulder, and that no shadows are cast. Careful tests should be made to discover any defects in eyesight and to see that suitable glasses are worn to correct any errors that exist and to prevent eye-strain.

Even in the best equipped stores covered in the author's survey a lack of proper *seats* for clerks was noticeable. The chair, the desk, and the foot rest should be adjusted to the individual and to the work to be done. These factors have, perhaps, been most successfully worked out at the modern telephone switchboard. The best chair * available for individual adjustment is doubtless the typist's chair. It is essential, however, that the worker understand how to adjust it in order to secure proper support for his back. Often a stool or foot rest is necessary for a very short person.

In one store where adjustable chairs were provided, they were most unpopular among some of the workers simply because the girls did not understand how to adjust them. Another objection raised was the difficulty of revolving the chairs easily to consult files placed at one side. On the other hand, a number of the more intelligent clerks in this force expressed great satisfaction and said that since adjustable chairs had been given them they had ceased to experience fatigue of the back. It would be an admirable scheme if every new employee, whether a clerk or a worker in a repair room or workroom, had her eyesight and her posture determined and was then carefully fitted to her place by someone familiar with physical requirements. Such a system would prevent unnecessary fatigue and ill health.

As a further aid in preventing fatigue among sedentary workers mid-morning and mid-afternoon exercises in a well-aired room, under the leadership of a physical director, have proved to be worth while. They furnish relaxation, refresh the workers and lead to an increased output.

The telephone switchboard has been commended for the excellent mechanical adjustment of seating and foot rests. Here a modified light is used to aid in seeing the light signals. In some of the stores surveyed the ventilation for the telephone girls was poor owing to the fact that the switchboard had to be shut off by partitions on account of nearby noises. Telephone work has a certain fascination and requires dexterity, but it tends to keep up the nervous tension in an already high-tension type of person. To meet the danger of fatigue, therefore, frequent short rest periods are desirable. A comfortable lounging chair, with light suitable for reading, placed near the switchboard and used in turn, has in some instances proved more successful than a distant rest room.

The tube room or cash room, now fortunately becoming less common owing to the extended use of the cash register, has certain common dangers. It is often in the basement and consequently dependent on artificial light and air. It is apt to be noisy and sometimes overcrowded. The hazard of dirty money is also present. Convenient provision should be made for moistening the fingers for sorting bills, and warnings should be given never to use the mouth for this purpose. Workers in these places in particular should acquire the habit of washing their hands thoroughly before eating.

Women are becoming more and more awake to the comfort and pleasure of comfortable *shoes*. To a girl who must stand most of the day a suitable shoe is invaluable. A number of stores carry good looking sensible shoes in their shoe departments and, recognizing the importance to their sales force of wearing such shoes, have offered a substantial discount to employees. One buyer of shoes tells me that he carries a college girl's shoe, which he sells to school girls, who admire college girls. In such a way he is able to fit with suitable shoes many persons who otherwise would be guided entirely by fashion in purchasing.

No one type of shoe is suited to all varieties of feet. For example, the growing girl

* A work chair especially adapted for use at tables or desks will be described in a subsequent article in this JOURNAL. Enquire before replacing chairs.

and the heavy, middle-aged woman need quite different shoes. In the store survey it was found that some workers kept extra shoes in their lockers for store use, and changed from their street shoes every morning. This practice might be of great value if more generally adopted, for it would very naturally result in the common use of a suitable store shoe.

Pin Ticket and String Cutter. — Two sources of injury which are often responsible for infected wounds are commonly found in stores — namely, the pin ticket and the string cutter. Pin tickets are used for marking a few articles of clothing. Even if they are put in by machines, they may still be a source of injury to the salesclerk and to the customer. They are a not uncommon source of trouble to the worker who inserts them by hand. Some other device for marking articles should be substituted. The counter string cutter has a point sufficiently sharp to inflict wounds. It can be rounded or dulled to a safe shape without reducing its usefulness.

Counter Wash Basins. — As the selling of white gloves requires the salesgirl to wash her hands frequently, small wash basins are usually provided, often below the glove counter. A mild soap, preferably in the form of liquid or powder, should also be supplied. A cake used in common is less desirable. Sufficient towels are usually furnished. It is quite common in winter, however, to find that a salesgirl has chapped or dried hands, and cannot clean them easily. To prevent chapping a hand lotion should be provided in a form convenient for easy application after each drying.

Sale of Food. — The public sale of food in stores dealing primarily in clothing and general merchandise carries certain risks. In our survey the soda fountain and ice-cream counter in some instances were found to be controlled by firms outside the store management — an arrangement which is always attended by some risk. Some of the soda fountains investigated were found to be well run and reasonably sanitary; others could not be passed without considerable criticism. The public does not distinguish between managements, so criticisms must be borne by the store. Similar responsibility is reflected on the store in the case of the chiropody, the manicure, the optical, and the hair dressing departments.

If a store is selling food to the public, the food handler must be not only neat and scrupulously clean but should also have been declared free from communicable disease by the store health department. The garbage must be systematically cared for and frequently removed. Perishable foods, such as milk, must be carefully guarded. Ice cream may also be a danger if it is not properly protected. The handling of food and money by the same person, as commonly happens at candy counters, is not a safe procedure.

Customers' restaurants are found in a few stores but in general they have been given up. If the management decides that a customers' restaurant is desirable, it must be made a model of cleanliness and attractiveness in order to be successful. These restaurants, I am told, seldom pay profit equal to the value of the space which they occupy. For sanitary equipment, healthy personnel, and safe practice, considerable responsibility is assumed by the store, whether or not it assumes the financial risk. Failure to maintain a high standard reflects directly on the store.

Conditions Affecting Both Workers and Customers

The customers, the buying public — largely women — are directly concerned with the conditions in stores. So far the questions considered are ones which principally affect the worker. The problems discussed below, however, concern equally the customer and the worker.

The location of the store is favorable according to the convenience of approach, the breadth of streets or open spaces around the store, the amount of sunlight and air, and the absence of noise, smoke, and dust nuisances. One store has an open canal at its rear, which in summer emits an odor sufficiently pungent to cause shoppers to sniff the air inquiringly. The answer received is "city politics."

Overcrowding. — The shopping public is often repelled by overcrowding, which is common on the street floor of department stores. To prevent this undesirable condition the entrances should be large and numerous and easy of access, the aisles should be broad and unobstructed, and adequate elevator service should be provided. Congestion may be somewhat relieved by removing to other parts of the store goods which are in considerable demand. The practice of allotting to departments space proportional to their earnings results, for example, in a whole floor being given to the furniture department in which may be found a half dozen shoppers, while the street floor is overcrowded with purchasers of small wares. The management alone can give due weight to the comfort and health of everyone by considering these factors in apportioning space.

Elevator Service. — Sufficient and convenient elevator service may create favorable contact with the public. Three stores in particular have strikingly capitalized this contact by the neatness and courtesy of their elevator operators and by the mechanical perfection of the service. The chief fault with the older type of elevator is that its entrance is so narrow that the time needed for filling and emptying is markedly lengthened. Thus, its convenience and efficiency in transportation are limited. The elevator about 10 feet wide by 6 feet deep, with doors folding in six sections, is the most efficient type which I have observed. To avoid confusion and loss of time one store has installed two banks of elevators in the center of the building — one side carrying passengers up, the other side bringing them down. At first thought this might seem inefficient. Careful observation has, however, proved this to be the more efficient service under the conditions found in this store. It took but a short time for the public to become accustomed to the system.

The natural tendency of the average elevator operator, like a street car conductor, is to order about the meek passengers. While safety may at times demand this, the American public naturally resents it. Courtesy here means much to the shopper who is often easily confused.

One store has successfully supplemented its inadequate elevator service by an escalator. Many people willingly walk down convenient stairways in preference to waiting for a crowded elevator.

Ventilation. — Under-ventilation is the common accompaniment of overcrowding, a discomfort to which many shoppers are very sensitive. Often a day's shopping is dreaded for this reason alone.

The basement store is particularly unpopular with some shoppers. This prejudice is often, but not always, justified. It is usually possible to supply sufficient artificial ventilation, except perhaps in rush times. The practical difficulty disclosed is the fact that the control of the ventilating system is in the hands of the engineer who has many other duties. Some effective check or follow-up system is needed to prevent under-ventilation. To avoid prejudice a basement store should, if possible, be over-ventilated. The practice which is now in use in many stores of running the ventilating system at night and sometimes over Sunday offers one solution of the ventilation problem. Fear of drafts results too often in under-ventilation which frequently increases the susceptibility to colds. However good the system

of ventilation may be, experience shows that a follow-up is necessary. Inspection should be systematized and made a regular duty if the problem is to be solved, and should, if possible, be superintended by someone with a medical point of view.

In large, crowded offices and workrooms, supplementary ventilation has been satisfactorily obtained by exhaust fans, placed in the upper sashes of the windows. Air ducts supplying fresh air are necessary in some offices where partitions have been carried to the ceiling in order to eliminate noise.

Cleaning. — A store cleaning system may perhaps be best judged by its results. A factor of special importance to the store health department is the health of the cleaning force who, being largely absent during store hours, may easily escape notice.

Vacuum cleaning is by far the most sanitary method of cleaning because dust and dirt are removed with no danger to the worker. The feather duster is at the other end of the scale of cleaning methods, and, like the common towel, to be suppressed, requires constant watchfulness. The oil dust cloth can often be substituted to do the same work.

Flooring is intimately connected with the cleaning job. A smooth surface with the fewest possible cracks is the best cleaning surface. Other factors besides cleaning must be considered in selecting flooring, such as appearance, cost, comfort and durability, including liability to injury from desk, chairs and truck wheels. From a health standpoint, comfort is a very important factor. Two kinds of floors cause discomfort to the salesperson, who must stand the greater part of the day; concrete or stone flooring is cold and hard; carpets, especially if they are soft and thick, are hot and tiring.

The flooring which best meets all the requirements is battleship linoleum. Especially does this meet the sanitary conditions of comfort and ease of cleaning. Cork, wood, tile and concrete are somewhat less favorable from a health standpoint. Carpets are often necessary and, if used, require thorough and frequent cleaning. The disadvantage of hardness in flooring may be partly compensated for by the use of matting and by the wearing of suitable shoes with rubber heels.

Dust Hazards. — Apart from the store cleaning system, dust hazards are sometimes found in certain store work, such as silver polishing, fur beating, upholstery workrooms and packing. The buffing and fur beating departments require exhausts to protect the employees. The use of paper or excelsior instead of hay does away with much of the dust in the packing and receiving of goods.

Drafts. — The entrance door problem of cold air and drafts during the winter has largely been solved by placing a generous heating surface either in the vestibule or just inside the revolving doors, thus heating the fresh air admitted with the customer. Glass shields are sometimes necessary to protect the worker and the goods on counters located nearby in the line of drafts.

Importance of Proper Industrial Relations and Medical Service

A follow-up system is the key to success in all sanitary matters. Experience already shows that lack of such a system has defeated more carefully prepared plans than any other factor. The human element is commonly responsible for poor ventilation in the modern well-equipped store. The three departments which are directly interested in good store housekeeping are the management, the engineering department, and the health department, all of which should be represented in formulating instructions and in following them through to results.

Thus, industrial relations become prominent in successful sanitation. One of the most satisfactory store sanitary systems which has been worked out owes its success to the ready welcome of all suggestions or reports to the engineering department. The chief of this department considers that the education of all store workers to report trivial matters immediately and freely is the key to success in the functioning of his store housekeeping system. All reports receive cheerful and prompt attention, even though it is recognized that perhaps one in four or five such reports needs action.

Proper industrial relations of a store require due consideration when any new measure, such as visiting nursing, is introduced. Publicity within the store, to be successful, requires a well-thoughtout plan. It should first be explained and discussed at the committee meetings of the management and of the sub-management or heads of departments, and then should be brought to the attention of all the workers by means of bulletins, by notices in their pay envelopes, or by articles in the store paper. Misunderstandings will thus be prevented and criticisms may be made which will result in wise alterations in the original plan.

In following up the system of sanitation, the health department should be on the alert to detect illness arising as the possible result of failure in some sanitary feature. A daily record form (see Figure 1) has been worked out and tried with success in a number of stores. One line only is used for each case. The monthly report results from addition of the columns. From the monthly report an annual report can readily be made, which will show, among many things, where illness is most common, and will often reveal a preventable cause. Such a daily record will enable a store to compare the healthfulness of its employees with that of workers in other stores, and may thus constitute an added attraction for prospective employees.

In the store emergency room it is a common practice for the nurse to give

FIGURE 1

HEALTH SERVICE DEPARTMENT

DAILY REPORT

Date

Department	Male or Female	Employee	Customer	Name	Medical	Surgical	Industrial Accident	Complaint	Treatment	Disposition of Case Remarks	Rest Room	Home	Seen by M.D.	Seen by Nurse	Advice	Recalls	Floor Calls	Transportation

immediate relief. Such relief has only too often consisted in drugging; the pill has frequently become almost the sole reliance. Unless medicines are given in accordance with standing orders of the doctor, who thus carries the responsibility, the emergency room is not even within the legal limits of medical practice. It is a lost opportunity to do any lasting good for the individual patient and consequently for the future welfare of the store.

When patients come for relief, they wish to receive good medical advice, which results from an intelligent understanding of their physical condition, their personal hygienic habits, their work, and even their play. If the future health of the employee is of value to the store, it is a matter of economy to furnish high-grade medical service.

To help build up a healthy, stable, and reliable personnel is the principal object and the chief justification of store medical service. It is, therefore, recommended that the emergency room be developed into a store health department with all that this term implies. Those who recognize early the importance of sanitary factors and adequate medical service, and who build wisely should first reap the benefits.

BOOK REVIEWS

Hygiene of Communicable Diseases: A Handbook for Sanitarians, Medical Officers of the Army and Navy and General Practitioners. By Francis M. Munson, M.D., Lieutenant, Medical Corps, U.S.N., Retired; Lecturer on Hygiene and Instructor in Military Surgery, School of Medicine, Georgetown University; Formerly Instructor in Medical Zoölogy, Georgetown College; Late Brigade Surgeon, and Provisional Brigade, U. S. Marines. Cloth. Pp. 793 with illustrations and index. New York: Paul B. Hoeber, 1920.

Dr. Munson has written a book which, in spite of the scope and rather minute detail, is still compact and physically manageable — an item of no small importance in the usefulness of a book. Due to the paragraph arrangement and an excellent index, the material is available for ready reference, so that the book should prove of value to all health officers, either civil or military, engaged in field work. It makes no pretence, I think, of being a laboratory manual, in which field its value would be much more questionable.

The author begins with a brief consideration of the various types of infecting agents and the theories of immunity. Chapters are devoted to such specific problems of sanitation as municipal, railway, military, prison, and school emergencies due to great disasters — *i. e.*, floods, earthquakes, etc. Dr. Munson is perhaps at his best when dealing with military sanitation, where the wealth of detail as to delousing, the disposal of human and animal excreta under various conditions, disposal of sink water, etc., would be invaluable in planning and administering the sanitation of a camp.

In the second part of the book, the diseases are grouped according to their mode of spreading and are considered individually. Parts of some valuable documents are quoted at length, such as the Interstate Quarantine Regulations of the Treasury Department, and War Department Orders and Directions Regarding Venereal Prophylaxis. The consistent use both in title and text of the term "communicable" instead of "infectious" or "contagious" is gratifying.

In spite of the introductory remark that no statement is made which is not supported by competent authority, we find, to our surprise, the unqualified statement that the etiological agent of measles is a filterable virus, and the etiological agent of influenza, the B. Influenzae. True, we read further on that "the consensus of opinion is that the bacillus of Pfeiffer, Bacillus Influenzae, is the specific causative agent, but that most cases are mixed infections." Even this does not appreciably lessen the surprise. Then, over two pages are devoted to what reads like a modern fairy tale, under the heading *The Pandemic of Influenza of 1918–19*, which has to do with a theory that the influenza bacillus is metamorphosed from the plague bacillus, and that the whole miserable pandemic started in China as pneumonic plague, and thence was spread into Germany by Chinese coolies, and thence all over Europe and America as influenza.

In the chapter on *Venereal Diseases*, Dr. Munson deals largely with the military and naval aspects of the question. He feels that "a medical program for civil communities equivalent to the military program for prevention and treatment should be encouraged." In so far as the treatment is concerned, Dr. Munson's recommendation might well be adopted, but the prevention in the military sense means, besides education and the restriction of prostitution, alcoholism, etc., the prophylactic station. There lies the difficulty. I know that some, and I have been given to understand that practically all, of the states have found it impracticable for one reason or another to endorse the prophylactic station as a part of their venereal program. Theoretically, if such stations work in the army, they should at least be of some value in a civil campaign against venereal disease. Practically, it is not difficult to see the obstacles.

When considering the control of diphtheria in an institution, the author recommends the administration of antitoxin to all the inmates, repeated every ten days or two weeks as long as cases appear. No mention is here made of the use of the Schick test and toxin-antitoxin immunization of susceptibles. True, these procedures are elsewhere mentioned for control in military organizations, but it would certainly be a mistake in an institution to frustrate the value of a test like the Schick test by the wholesale administration of antitoxin.

Under the discussion on measles the author argues effectively against closing the schools in the presence of an epidemic. He also makes a plea for education against the exposing of young children. The not at all uncommon prac-

tice of exposing young children to measles to "get it over with" cannot be too severely condemned, when we consider that about 80 per cent. of the deaths from measles occur during the first three years of life, while in 1918 in Massachusetts only about 16 per cent. of all the cases of this disease occurred in this age group.

The author states that an attack of yaws confers immunity. There seems to be no reason to suppose that a person cured of yaws is any more immune to reinfection than is a person cured of syphilis. Immunity in syphilis is, to say the least, open to question. With the almost unquestioned short viability of the Treponema pertenue outside the body, there seems to be but little need for the thorough disinfection recommended to prevent the spread of yaws.

There are many good points made by Dr. Munson, such as the paucity of public comfort stations in American cities as compared with European cities; the danger from the broadcast distribution of raw human excreta along railways particularly when they border public or private water supplies; that the ordinary drip "disinfecting" machines in toilets and urinals are of service only in adding an unpleasant odor to those already present; that a "school without a playground is an educational deformity," etc. He gives regulations that should be in force in all barber shops. The average barber shop is certainly a sanitary nightmare. He also gives points of value in inspecting markets, abattoirs, etc., and many other suggestions which will, as has been said, be found of value to the health officer in the field. — *George H. Bigelow.*

Organisation Industrielle, Médecine Sociale et Éducation Civique en Angleterre et aux États-Unis. By René Sand, Inspecteur principal au Service médical du Travail; Agrégé de l'Université de Bruxelles; Membre correspondant de l'Académie royale de Médecine de Belgique; Médecin de régiment de réserve à l'Ambulance de l'Océan. Paper. Pp. 896 with index and table of contents. Paris: J.-B. Baillière et Fils, 1920; Brussels: Maurice Lamertin, 1920.

Dr. René Sand has recorded in this large book the impressions which he received during two visits to the United States and one to England in 1918 and 1919.

The title of the volume only suggests the multiplicity of subjects of which he writes. The Taylor system, industrial relations, industrial safety, the physiology of fatigue, child labor, unemployment, settlement houses, public health activities and social reconstruction — these and many other topics are discussed at length.

The work must be termed superficial — but that the author doubtless intended it should be. It is, however, in many instances very inexact, as any such record must naturally be, when its author is a kindly person *en tour* in a strange land and at the mercy of a multitude of individual enthusiasts all arrayed in their best official robes, each with his best foot forward. — *Wade Wright.*